Bridging Model-Based Systems Engineering and Model-Based Design

Bill Chown and Anthony Nicoli
Forces Challenging Aerospace & Defense Industry Profitability

- Winning New Business
- Competitive Margin Pressure
- Production Ramp
- Cost Control
- Just-in-Time, Quality Deliveries
- Supply Chain Collaboration
- Cost of Quality
- Regulatory Compliance
Boeing $9.2B TX Trainer Win Built on Model Based Engineering & Production

Boeing’s winning bid for the T-X trainer contract came in at least $10 billion less than the U.S. Air Force’s original estimate.

Challenges of integrating model based engineering with model based manufacturing.

Aviation Week Aerospace & Defense Daily Report “Inside Boeing’s Secret Formula To Win T-X” May 17, 2019
Distributed System Engineering

- One technical system described from different perspectives
- One technical system, but a lot of distributed information
- Distributed information is challenging for collaboration
Difficult to comprehend complete product definition
- Poor collaboration, coordination and planning
- No cross-domain traceability or dependencies
- Inconsistent versioning of artifacts
- Cannot configure data and variants across areas
- Lack of cross-domain impact assessment
- Out of date information

Problems with isolated information and domain silos
Integrated Business Views Across the Digital Thread

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Digital Thread Navigator

Role Based Dashboards

Cockpit Apps

Digital Enterprise Cockpit

Mendix RAD for Your Cockpit Apps

Siemens Digital Enterprise Suite

Program and Project Management, Search, Reporting & Analytics, Change and Configuration Management, Process Orchestration

Requirements Management

Systems Modeling

Mechanical

Electrical

Software

Manufacturing Planning

Manufacturing Execution

Service Planning

Performance in Field (IOT)

Enterprise Digital Thread

(Semantic Data Model, Traceability, Accountability, Impact Analysis)
The Requirements (from the user perspective!)

- Changes to current practices should be minimal and incremental
- Every participant should have transparent access
- No changes should go unaddressed
- Incomplete work should be immediately noticeable
- Shared resources should be allocated effectively
- No work should be done twice (or more!)
- Every participant should access information in a familiar view
- Reporting upon what has been done should be no extra work
Moving from a document era to a digital engineering era with information flow across the lifecycle.
Looking at the Process – the Systems Engineering ‘V’

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Source: Mitre

MBSE drives towards Design

Model Based Design drives Implementation
Systems Engineering: Holistic Product Development
Multi Discipline Landscape

Bridging Model-Based Systems Engineering and Model Based Design applies across multiple disciplines, flows and domains of the complex overall process.
Increased Electrification Drives Power Demand
Aircraft differentiation spurs electrification

Magnitude of Impact:

25% EE Content Growth Every 5 Years

10x Power Demand Over 50 years

EWIS now 3% of Aircraft Weight

EWIS Cost Grows Faster than Content

http://eprints.nottingham.ac.uk/51652/1/Electrical%20Power%20Generation%20in%20Aircraft.pdf
Model-based Electrical Systems Development Flow

Multi-Domain Requirements & system architecture

E/E Domain Architecture

DEFINE

DESIGN

MANAGE

PRODUCE

MAINTAIN

In-Vehicle Networks

Embedded Software

Electronics

Electrical

MCAD Co-Design and PLM Integration

Model Based Enterprise
Capital – MBSE Drives Generative & Connected Engineering

Normalizing the myriad of inputs within a common model

May be sourced from and integrated with PLM / ALM systems

- Largely commoditized - Value usually derived from incorporation within a downstream flow

Supported by both In-Tool and External Verification & Validation capabilities
Capital – MBSE Drives Generative & Connected Engineering

Normalizing the myriad of inputs within a common model

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Normalize Functional Models within Capital

May be sourced from and integrated with PLM / ALM systems

Define Domain

Functional Models (SysML, Visio, Excel…)

Utilize in Downstream Capital Client Applications

Supported by both In-Tool and External Verification & Validation capabilities

Normalize Functional Models within Capital

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Define Domain

Functional Models (SysML, Visio, Excel…)

Utilize in Downstream Capital Client Applications

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Continuity – Traceability – Auditability through the Digital Thread

Digital Enterprise Cockpit

Formats
- UML
- SysML
- ARXML
- Excel
- DBC
- On demand
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**Capital – MBSE Drives Generative & Connected Engineering**

*Normalizing the myriad of inputs within a common model*

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**Normalize Functional Models within Capital**

- Define Domain
- Continuous Digital Thread
- Functional Models (SysML, Visio, Excel…)
- Systems & Requirements

May be sourced from and integrated with PLM / ALM systems

**Network Signal**
- Media Type
- Multiplexed
- Bit-size
- Frequency
- MUX Load

**Software Function**
- SW Type
- RAM
- ROM
- FLASH
- Runtime
- Frequency
- CPU Load

**Driver Function**
- Driver Type
- Weight
- Space
- Power Diss.
- Heat Diss.
- Cost
- Power

**Electrical Signal**
- Electrical type
- CSA
- Length
- Space
- Weight
- Power
- Power Dissipation
- Heat Dissipation
- Cost

**Hardware Function**
- Type
- Weight
- Space
- Height
- Power

**Option Codes**
- Shared Signals
- Continuity – Traceability – Auditority through the Digital Thread
- Digital Enterprise Cockpit

Supported by both In-Tool and External Verification & Validation capabilities
Assess Electrical System Architecture BEFORE Design
Functional Model: Validate & Optimize via Relevant System Metrics

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Generative & Connected Engineering for the Product Lifecycle
Models, Constraints in Agile development

Integrated with both MCAD and PLM / ALM Systems

Normalize **Functional Models** in Capital

Capital Portfolio

Multiple sources of **Functional Models**
(SysML, Visio, Excel...)

Generate **Architectures** for Logic, NW, HW, SW

**DEFINE** Domain

Extract Discreet **Logical Systems**

**DESIGN** Domain

Extract Discreet **Harness Designs**

**PRODUCE** Domain

Extract & Publish **Electrical Service Data**

**MAINTAIN** Domain

Supported by both In-Tool and External Verification & Validation
Connected Engineering for the Electronic MBE
A portfolio of tools support the entire electrical engineering life cycle

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Integrated with both MCAD and PLM / ALM Systems

- Normalize **Functional Models** in Capital
- Generate **Architectures** for Logic, NW, HW, SW
- Generate **Electronic Distribution** System
- Generate **MB Logic Representation**
- Generate **Physical Implementation**
- Extract MB-BoF Electronic SubSystem
- Extract Harness Definition Harness Designs (ICD)
- Capital Devices

Multiple sources of **Functional Models** (SysML, Visio, Excel...)

Supported by both In-Tool and External Verification & Validation
Supporting the Model Based Enterprise
Domain Architectures

Sourced from and integrate-able with PLM / ALM systems

Normalize Functional Models within Capital

Multiple sources of Functional Models (SysML, Visio, Excel…)

Generate Architectures for Logic, NW, HW, SW

Define Domain

Software Components

Avionics Networks

Roadmap

Electrical Distribution

Manufacturing Solutions

Service Solutions

Supported by both in-tool and external Verification & Validation capabilities
Creating the Electrical, Configuration Controlled, Digital Twin

How can we use this?
Closing the Loop in Bridging MBSE and MBD

- Conceptual design and requirements derive predicted results
- Test and Evaluation provide actual characteristics
Closing the Loop in Bridging MBSE and MBD

- Conceptual design and requirements derive predicted results
- Test and Evaluation provide actual characteristics
- Interrogating the Digital Twin(s) reveals the match / differences
Address the impact of electrical complexity on compliance
Accurate Verification: Scalable, Automated and Continuous

Exploiting the configuration-controlled digital twin

Comply by construction via constraints and automation

Continuously verify design compliance

Check it, analyze it, virtually verify it - as you design it!

Then, Automatically Generate the Delivered Evidence
Those who adapt & lead, DOMINATE.
The widening gap in digital productivity

The top 5% of companies are dominating the economy by exploiting digital competencies

The Best Versus the Rest: The Global Productivity Slowdown, Divergence Across Firms And The Role of Public Policy, OECD Productivity Working Papers

Data is from 24 OECD countries.
Aerospace Companies Who Have Made the Change And Are Reaping Quantifiable Benefits Today

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Reduce platform weight to increase payload capacity
Optimized by integrating electrical and MCAD design, orchestrated by integration with Teamcenter

Increase efficiency with an improved electrical process
Modern Helicopters have complex wiring interconnections
20% reduction in wiring system design time compared with previous norms

Transform business process with better design systems
Architected the electrical system using generative design.
Merged systems definition with packaging requirements, reducing downstream design cycles

Enterprise commitment to the digital thread
Organizational transformation via automation & digitalization.
Meet the challenges of next gen electrical design & manufacturing.

Pilatus
“keeping our products ahead of the market requires the creation of intimate connections between avionics and other aspects of the aircraft, such as mechanical systems”

KAI
“Capital gives a substantial productivity boost … tools are easy to use, with superior automation, and ensure high level of data correctness”

Bell
Bell Helicopter were able to significantly streamline their wiring design processes on the Bell 525 Relentless program

Boeing
“Our partnership with the Siemens team will combine best-in-class electrical design tools with Boeing’s vast experience and knowledge in our 2CES transformation of electrical design”
Participate in the Ecology of Industry Leaders
By Bridging Model Based Systems Engineering & Model Based Design

- Reduce Program Risk
- Gain Competitive Advantage
- Improve Productivity

- Meet Key Program Milestones
- Retain Industry Relevance
- Enable Growth in Profitability
Thank You!
Appendix

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Performance and Quality Feedback

Digital Twin Product

Digital Twin Production

Digital Twin Performance

Continuous Improvement across Product Lifecycle
Systems Engineering: Holistic Product Development
The Industry’s Most Comprehensive Solution Portfolio

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